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# COMPARATIVE STUDY ON COMPRESSIVE AND FLEXURAL STRENGTH OF STEEL FIBRE REINFORCED CONCRETE (SFRC) USING FLY ASH

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**ABSTRACT**

*The objective of this work is to study the behaviour of fly ash content with Steelfibres in concrete. In this work we focussed on the experimental results of M-30 grade of concrete with Hooked end steel fibres (HESF) ofvolumefractions,1%, 2% & 3% increment on absolute weight of concrete with aspect ratio (l/d) 80 and also cement is partially replaced with 10%, 20%, 30% of fly ash. Results obtained from compressive strength and flexural strength tests have been analyzed and comparedwith a control specimenfor 7 days and 28days are expressed graphically.*

**Key words:** Compressive strength, flexural strength, steel fibre reinforced concrete, fly ash, absolute weight of concrete.

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## 1. INTRODUCTION

Concrete is one of the most versatile building materials. It can be cast to fit any structural shape from a cylindrical water storage tank to rectangular beam or column in a high-rise building. The advantages of using concrete include high compressive strength, good fire resistance, high water resistance, low maintenance, and long service life [1].The disadvantages of using concrete include poor tensile strength, low strain of fracture and

formwork requirement. The major disadvantage is that concrete develops micro cracks during curing [2]. It is the rapid propagation of these micro cracks under applied stress that is responsible for the low tensile strength of the material. Hence fibres are added to concrete to overcome these disadvantages and fly ash helps an admixture for improving the workability of concrete [3].The main reasons for adding steel fibres to concrete matrix is to improve the post-cracking response of the concrete, i.e., to improve its energy absorption capacity and apparent ductility, and to provide crack resistance and crack control. Also, it helps to maintain structural integrity and cohesiveness in the material [4]. FRC has developed new applications for control and reinforced concrete in the following properties: it has higher strength in flexural, tensile, shear, impact resistance and it also has special properties like crack resistance, failure toughness and better ductility [5]. The purpose of this study is to understand the compressive strength and flexural strength of hardened concrete along with various mix proportions of steel fibres and fly ash.

## 2. MATERIAL SPECIFICATION

### 2.1. Cement

The cement used in this study is ordinary portlandcement (OPC) of 43 gradeconforming to IS 12269-1987. Table No.1 shows the physical properties of cement.

**Table 1** Physical properties of cement

| Properties | Result obtained |
|---|---|
| Specific gravity | 3.15 |
| Initial setting time | 43minutes |
| Final setting time | 125 minutes |
| Consistency | 33% |

### 2.2. Fine Aggregate

Locally available sand went through 4.75mm IS sieve. Natural river sand according to zone II Seems to be IS: 383-1987 was utilized. Table No.2 shows the physical properties of fine aggregate.

**Table 2** Physical properties of fine aggregate

| Properties | Result obtained |
|---|---|
| Specific gravity | 2.65 |
| Fineness modulus | 3.3 |
| Water absorption | 2% |

### 2.3. Coarse Aggregate

#### *2.3.1. 20mm Size Aggregates*

Crushed aggregates available from nearby sources were taken as per IS 383-1987. We have considered60% of 20mm size aggregate in the total mixture to study the physical properties which are given in Table 3.

**Table 3** Physical properties of coarse aggregates

| Properties | Result obtained |
|---|---|
| Specific gravity | 2.7 |
| Fineness modulus | 7.12 |
| Water absorption | 0.5% |

#### *2.3.2. 10mm Size Aggregates*

Crushed aggregates available from nearby sources were taken as per IS 383-1987. We have considered 40% of 10mm size aggregate in the total mixture to study the physical properties which are given in Table 4.

**Table 4** Physical properties of coarse aggregate

| Properties | Result obtained |
|---|---|
| Specific gravity | 2.66 |
| Fineness modulus | 2.73 |
| Water absorption | 1.2% |

### 2.4. Fly Ash

The ash produced at thermal power stations by burning of coal and lignite is known as fly ash or pulverized fuel ash. Fly ash is an artificial pozzolanic material which is used as cement replacement material. The fly ash used in this exploration was Class F, taken from the nearby NTPC of Vijayawada. The physical properties of class F fly ash were shown in Table No.5

**Table 5** Physical properties of class F fly ash

| Properties | Result obtained |
|---|---|
| Specific gravity | 2.13 |
| Fineness modulus | 7.6 |
| Consistency | 26% |

### 2.5. Water

Ordinary portable water used in this experimentation for both mixing and curing.

### 2.6. Fibres

Steel fibres are procured from Stewols Pvt. Ltd. Nagpur. The type of fibres used was hooked at both ends with aspect ratio 80 having length 60mm and diameter 0.75mm as shown in Fig.1 the physical and chemical properties of steel fibres as shown in Table 6 and Table 7.

**Figure 1** Hooked end steel fibres.

**Table 6** Physical properties of steel fibres

| Properties | Values |
|---|---|
| Specific gravity | 7.8 |
| Length | 60mm |
| Diameter | 0.75mm |
| Aspect ratio | 80 |
| Shape | Hooked at both end |
| Tensile strength | 1023 $N/mm^2$ |
| Modulus of elasticity | 200 GPa |

**Table 7** Chemical composition of steel fibres

| Chemical composition of mild steel wire | Percentage (%) |
|---|---|
| C | 0.074 |
| Mn | 0.36 |
| Si | 0.065 |
| P | 0.01 |
| S | 0.009 |

## 3. EXPERIMENTAL PROGRAMME

### 3.1. Workability Test

Workability test can be performed by conducting slump test on conventional concrete and fibre reinforced concrete (FRC) according to IS: 1199-1959.

### 3.2. Mixing

The concrete mixture can be produced by hand mixing. After weighing all these components such as cement, fly ash, fine aggregate, coarse aggregate was mixed thoroughly. To this mixture required amounts of steel,fibres were added in the percentage. The fibres were uniformly mixed with sprinkler action by the hand. The water was added to this mixture without any loss in water content while mixing operation was done.

### 3.3. Casting and Curing

The moulds were filled by the concrete mixture with 0%, 1%, 2% and 3% of fibres and the fly ash was added with 0%, 10%, 20% and 30% by cement weight. Now the mixture was filled up in moulder cubes and these cubemouldswere undergone vibration using table vibrator equipment. After the vibration was completed the top surface of mould was smoothly leveled. The specimens were de-moulded after completion of 24 hours and transferred to the curing tank.

### 3.4. Compressive Strength Test

One of the salient property for most structural application is the compressive strength of concrete. To determine the Compressive strength of concrete, cubes with the specified dimensions 150x150x150mm were used. The specimens were cured for 7-28 days in the curing tank after completion of curing process the specimens were undergone for testing in the laboratory, on compression testing machine as per the norms of I.S.516-1959.For each

percentage of mixture three specimens were tested and the failure load values were noted. The compressive strength of concrete can be determined as using below formula.

Compressive Strength of cube = (Load at Fracture / Area of cross-section)

The average value can be taken from the three specimens of compressive strength test results.

The results were shown in Table 9 Fig. 2 & 3 shows compressive strength of control concrete cube and steel fibre fly ash concrete cube after testing and graphical representation of compressive strength was shown in Fig.4

**Figure 2** Compressive strength of control Concrete cube after testing.

**Figure 3** Compressive strength of steel fibre fly ash concrete cube after testing.

**Table 9** Result of compressive strength at 7 & 28 days

| S.No | Various percentages of mix proportions | Compressive strength ($N/mm^2$) | |
|---|---|---|---|
| | | 7 days | 28 days |
| 1 | M0(0% F.A & 0% S.F) | 27.09 | 40.69 |
| 2 | M1(10% F.A & 1% S.F) | 24.85 | 35.46 |
| 3 | M2(10% F.A & 2% S.F) | 24.12 | 35.75 |
| 4 | M3(10% F.A & 3% S.F) | 27.32 | 38.51 |
| 5 | M4(20% F.A & 1% S.F) | 22.96 | 30.81 |
| 6 | M5(20% F.A & 2% S.F) | 24.99 | 35.67 |
| 7 | M6(20% F.A & 3% S.F) | 23.90 | 34.37 |
| 8 | M7(30% F.A & 1% S.F) | 21.94 | 30.22 |
| 9 | M8(30% F.A & 2% S.F) | 23.83 | 33.86 |
| 10 | M9(30% F.A & 3% S.F) | 21.02 | 29.93 |

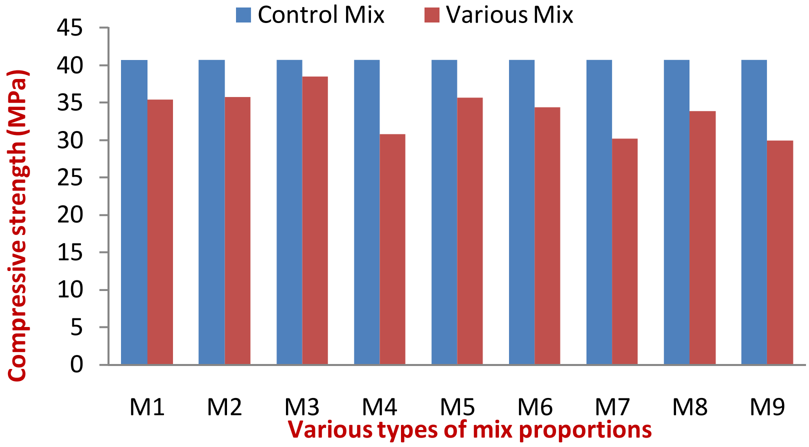


**Figure 4** Compressive strength of cube at the age of 28 days

### 3.5. Flexural strength Test

Flexural strength is one which measures the tensile strength and also unreinforced concrete beams to resist failure load in bending. It is also known as modulus of rupture or fracture strength. Testbeam specimens of dimension 150x150x700mm were cast. After the casting of specimens was done, those were de-moulded and transferred to the curing tank and allowed to cure for 28 days. The strength was tested under two point loading as per I.S.516-1959, the 600mm of effective span divided into three equal parts. Those were rest on a testing machine of flexural strength. While testing was done the load was increased gradually and the failure point load was noted at which the beam was cracked. For each percentage of mix two beams were tested and the average value was considered. The flexural strength can be calculated using below formula.

$$\text{Flexural Strength (Mpa)} = \frac{PXL}{bXd^2}$$

Here, P = Failure Load, L = Distance between the supports from centre to centre = 600mm

b = specimens width = 150mm, d = specimens depth = 150mm.

Fig.5 & 6 shows the flexural strength of plain cement concrete beam and steel fibre fly ash concrete beam. The results were shown in Table No.10 and graphical representation of flexural strength was shown in Fig. 7

**Figure 5** Flexural strength of plain cementconcrete beam after testing

**Figure 6** Flexural strength of steel fibre fly ash concrete beam after testing

**Table10** Result of flexural strength at the age of 28 days.

| S.no | Various percentages of mix proportions | Flexural strength ($N/mm^2$)@28 days |
|---|---|---|
| 1 | M0(0% F.A & 0% S.F) | 4.62 |
| 2 | M1(10% F.A & 1% S.F) | 5.31 |
| 3 | M2(10% F.A & 2% S.F) | 5.49 |
| 4 | M3(10% F.A & 3% S.F) | 5.66 |
| 5 | M4(20% F.A & 1% S.F) | 6.19 |
| 6 | M5(20% F.A & 2% S.F) | 6.36 |
| 7 | M6(20% F.A & 3% S.F) | 6.73 |
| 8 | M7(30% F.A & 1%S.F) | 4.74 |
| 9 | M8(30% F.A & 2% S.F) | 4.88 |
| 10 | M9(30% F.A & 3% S.F) | 4.95 |

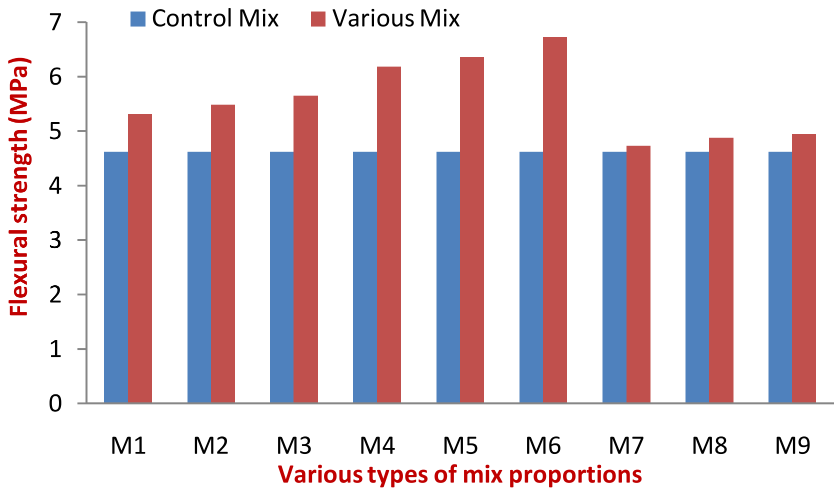


**Figure 7** Flexural strength of beam at the age of 28 days

## 4. RESULTS AND DISCUSSION

Effect on compressive strength and flexural strength of concrete due to steel fibres and fly ash is shown in Table No.9 &10. A sequence of cubes and beams are cast with various percentages of mix proportions (fly ash 10%, 20%, 30% andsteelfibres 1%, 2%, 3%). Proper care should be taken while handling of specimens due to higher aspect ratio. The results obtained from tests conducted on specimens the following discussions are made with respect to conventional concrete.

- The compressive and flexural strength of control mixes is constant when compared to various types of mix proportions.
- The compressive strength of M1 and M2 mix proportions was decreased by 12.85% and 12.14% with respect to control concrete.
- Alternative percentage changes in compressive strength were observed from the mix proportions M3 to M9
- The optimum compressive strength obtained is 38.51 MPa at the mix type M3 with respect to conventional concrete.

- The flexural strength of mix types M1, M2, M3, M4, M5 and M6 was gradually increased by 14.94%, 18.83%, 22.51%, 33.98%, 37.66% & 45.67% when compared to conventional concrete.
- The flexural strength of mix types M7, M8 & M9 was increased by 1.95%, 3.68%and 5.63% with respect to control concrete and is less than M1 to M6 mixes.
- The optimum flexural strength obtained is 6.73 MPa at the mix type M6 and increased by 45.67% with respect to control concrete.

## 5. CONCLUSIONS

The following conclusions are made from the present investigation

- It is observed that in steel fibre fly ash concrete beam the cracks are interlocked and ductility is found to increase at higher fibre content when compared to plain cement concrete beam.
- Workability of concrete is improved when fly ash percentage increases and then decreases at higher fibre content.
- The mix typesM6, M5, M4 and M3 gives better flexural strength at the age of 28 days.
- The mix type M3 gives good compressive strength at the age of 28 days.
- The optimum flexural strength obtained is 6.73 $N/mm^2$ with the addition of 3% steel fibres and 20% replacement of cement by flyash.
- Compressive strength gradually increases as the percentage of steel fibres increases.

## REFERENCES

[1] S.Devendran and E.Saravananithin,"Experimental investigation on behavior of steel fibre reinforced concrete with fly ash",*International Journal of Science and Engineering Research (IJ0SER)*, Vol.4, pp 3221-5687, 2016.

[2] S.N.Khadake, C.G.Konapure,"An Experimental Study of Steel Fibre Reinforced Concrete with Fly Ash for M35 Grade", *International Journal of Engineering Research and Applications (IJERA)*, Vol. 3, Issue 1,pp.950-953,2013.

[3] A.M.Shende, A.M.Pande and M.G.Pathan,"Experimental Study on Steel Fibre Reinforced Concrete for M-40 Grade", *International Refereed Journal of Engineering and Science (IRJES)* Vol. 1, Issue 1, PP. 043-048,2012.

[4] P.R.Singh, A.Goel, S.Thakur and N.D.Shah, "An Experimental Approach to Investigate Effect of Steel Fibres on Tensile and Flexural Strength of Fly ash Concrete", *International Journal of Scientific Engineering and Applied Science (IJSEAS)*, Vol.2, Issue-5,pp 384-392,2016.

[5] P.Shweta and R.Kavikar,"Study of Flexural Strength in Steel Fibre Reinforced Concrete", *International Journal of Recent Development in Engineering and Technology (IJRDET),* Vol 2, Issue 5, pp 13-16, 2014.

[6] V.S.Vairagade, K.S.Kene and T.R Patil,"Comparative Study of Steel Fibre Reinforced Over Control Concrete", *International Journal of Scientific and Research Publications (IJSRP)*, Vol 2, Issue 5, pp 1-3, 2012.

[7] R.Madheswaran, S.A.Singh and K.S.Sathyanarayanan,"Experimental study on hardened concrete by using steel fibres with mineral admixture", *International journal of civil engineering and technology* (*IJCIET),* Vol 5, Issue 5, pp 114-122, 2014.

[8] F.A.Laherwal and D.Diwaker, “Experimental Study of Fly Ash Concrete with Steel Fibre *International Journal of Emerging Technology and Advanced Engineering (IJETAE),* Vol 6, Issue 8, pp 62-70, 2016.

[9] Ch.J.Chandu and J.Supriya, “Mechanical Properties of Steel Fibre Reinforced Concrete Composites”, *International Journal of Computer Engineering In Research Trends (IJCERT),* Vol 2, Issue 12, pp. 941-946,2015.

[10] M.A.Farooq and M Shafi, “Laboratory Characterisation of Steel Fibre Reinforced Concrete for varying Fibre Proportion and Aspect Ratio, *International Journal of Emerging Technology and Advanced Engineering (IJETAE)*, Vol 3, Issue 2, pp 75-80,2013.

[11] I.S. Ibrahim and M.B.C.Baker, “Effects on mechanical properties of industrialised steel fibres addition to normal weight concrete”, Science Direct, Procedia Engineering Vol 14 pp2616–2626

[12] Resmi Madhan and K V Sudheer,“Experimental study on the strength properties of fly ash based steel fibre reinforced concrete”, *International journal of Modren Trends in engineering and science (IJMTES)*Vol 3,2016.

[13] L.N.Vairagade and V.M.Bhedi, “Comparison of Strength between Steel Fibre Reinforced Concrete and Conventional Concrete”, *International Journal on Recent and Innovation Trends in Computing and Communication (IJRITCC)*, Vol 3 Issue: 2, pp 005-010, 2015.

[14] A.M. Shende and A.M. Pande,“Comparative study on Steel fibre reinforced Cum control concrete under flexural and deflection”, *International journal of applied engineering research, dindigul (IJAER)*, Vol 4, PP 0976-4259, 2011.

[15] D.B.Mohite and S.B.Shinde, Experimental Investigation on Effect of Different Shaped Steel Fibers on Flexural Strength of High Strength Concrete. *International Journal of Civil Engineering and Technology*, 4(2), 2013, pp. 332–336.

[16] TK, Biju Mathew and Dr. Benny Joseph, Experimental Study on Effect of Short Steel Fibre Reinforcement on Laterized Concrete. *International Journal of Civil Engineering and Technology*, 7(4), 2016, pp.380–392.